country and in America, that certain radical reforms were needed in the methods of education in medicine. But our American colleagues have been fortunate in having the opportunity and the means for building new schools of medicine to meet the new circumstances and for making drastic changes in their methods of teaching which a variety of circumstances has hitherto prevented us from attempting in Britain. Now that the Rockefeller Foundation, by its magnificent generosity, has made it possible for us to embark upon the difficult sea of reform, it is particularly interesting and instructive to study the policy adopted in the more advanced schools of America during the twenty-seven years since the Johns Hopkins Medical School gave the study of medicine in America a new aim and a higher ideal. Though we are a quarter of a century behind our American colleagues in making a start, our delay has given us the advantage that we can profit by the experiments made on the other side of the Atlantic.

It is not generally recognized here how thoroughly the leaders of medical education in America explored every possible method of education throughout the world, and how much devotion and thought they have expended on experiments to discover, by truly scientific methods, how best to employ the few years that the medical student can devote to the training for his profession. Those who want to understand something of the spirit and the high deals that have inspired the American leaders in this great reform movement should read the account of their work and aims in the volume "Medical Research and Education," issued by the Science Press in New York in 1913. Briefly expressed, the matters upon which chief insistence is placed are as follows: The absolute necessity of (*a*) an adequate preliminary education and a serious university training in the basal sciences, physics, chemistry, and biology, without which foundation it is impossible for the student really to profit from his training in medical science; and (*b*) a method of practical teaching in all branches of professional work, whereby the student can, so far as possible, investigate for himself the facts and theories of each subject under the direction of men who are themselves engaged in research work, and not rely mainly upon lectures and demonstrations to give him merely the *results* of other people's work. In other words, the aim of the reform is to train the student in scientific methods rather than to "cram" him with traditional lore.

* * * * * * * *

The great development in the science of anatomy during the last thirty years has been due mainly to the use of the microscope for the investigation of the structure of the body and for the study of embryology. British anatomy has been hampered by the lack of the facilities for teaching these vital parts of the subject, and has suffered enormously from the lack of stimulating daily contacts with them. In other countries, and especially in America, the cultivation of histology and embryology has not only made anatomy one of the most active branches of medical study and research, but also brought the work of the department into close touch with physiology, biochemistry and pathology, to the mutual benefit of all these subjects, and especially to the student who has to integrate the information acquired in the different departments. It was the radical reforms effected in the teaching of anatomy by the late Professor Franklin Mall at the Johns Hopkins Medical School in 1893 that played the chief part in starting the great revolution in medical education in America. The stimulating influence of the abolition of the methods of medieval scholasticism in anatomy and the return to the study of Nature and to the use of experiment brought about a closer cooperation with other departments and a general quickening of the students' interest in the real science of medicine.—*Nature.*

---

## SCIENTIFIC BOOKS

*A new Morphological Interpretation of the Structure of Noctiluca and its bearing on the Status of the Cystoflagellata* (Haeckel). By Charles A. Kofoid. University of California Publications in Zoology, Vol.

19, No. 10, pp. 317–334, one plate, two text-figures. February 13, 1920.

Professor Kofoid, the leading student of the Flagellata, in a brief but important paper, discusses convincingly the morphology and relationship of *Noctiluca*. The data and their bearing are well indicated in the author's summary, as follows:

1. Notiluca is a tentacle-bearing dinoflagellate with a sulcus, girdle, and longitudinal and transverse flagella.

2. The sulcus is longitudinal and midventral. It includes the apical trough and the recessed oral pouch and cytostome.

3. The tentacle arises from its posterior end.

4. The girdle has hitherto been overlooked. It is a shallow trough at the left of the sulcus and at right angles to it. It is seen best in small individuals.

5. The longitudinal flagellum is reduced and lies within the oral pouch. The transverse flagellum is represented by the prehensile tooth at the proximal end of the girdle at the left of the base of the longitudinal flagellum. This organ exhibits structural undulations and spasmodic or rhythmical contractions.

6. Distention by hydrostatic vacuoles, with flotation replacing active locomotion, has led to degeneration of the flagella and their reduction in size, and to the almost complete disappearance of the girdle.

7. *Noctiluca* belongs in the Noctilucidæ, a family of the tribe Gymnodenioidæ, with *Pavillardia*, another tentaculate, naked, non-ocellate dinoflagellate.

8. There is no morphological justification of a separate order of flagellates to hold *Noctiluca*, such as the Cystoflagellata Haeckel.

9. The Cystoflagellata may be retained as thus emended to receive *Leptodiscus* and *Craspedotella* pending discovery of their affinities.

MAYNARD M. METCALF
THE ORCHARD LABORATORY,
OBERLIN, OHIO

## SPECIAL ARTICLES

### THE EFFERENT PATH OF THE NERVOUS SYSTEM REGARDED AS A STEP-UP TRANSFORMER OF ENERGY

THE properties of nervous tissue which fit it for its peculiar rôle in the animal economy are given by Sherrington as (1) excitability (2) spatial transmission of impulses and (3) control of the liberation of energy in contiguous tissues. Pawloff and others have emphasized the rôle of the peripheral sense organs as energy transformers, since the energy of light or heat or sound is transformed, by appropriate mechanisms, to the energy of a nerve impulse. Lucas and Adrian's all or none hypothesis of nerve conduction calls attention to another aspect of the work of the nervous system as a transformer of energy. According to this hypothesis, the nerve impulse conducted by any single nerve fiber is at all times the maximum impulse which it is capable of conducting. The evidence in favor of this view appears to be steadily accumulating, although there are still conditions under which the energy relationships are not clear. The efferent paths of the nervous system appear to me to furnish additional confirmation of the general truth of the hypothesis.

Neurologists have frequently commented on the relatively few nerve fibers in the main motor tracts of higher animals, *i. e.*, the pyramidal tracts, as compared to the number of fibers in the ventral roots of the spinal nerves and the great mass of muscles to be activated. According to von Monakow, Redlich, Schäfer and others, fibers of the pyramidal tract do not end directly about the cells of origin of the motor nerves, but about some intermediate or intercalated cells in the spinal cord. Von Monakow has supposed that each of these intermediate cells comes into relation, through the branching of its processes, with more than one motor cell in the spinal cord. Furthermore, the axone of each peripheral motor nerve may branch on its way to its effector. There is a possibility, therefore, that each descending fiber in the pyramidal tract of the spinal cord may ultimately be able to actuate several terminal axones in the peripheral motor system. Suppose that one pyramidal fiber may, through the intercalated neurone, come into relation with three cells of origin of peripheral fibers,